The Paradigm Shift of Coursework Development Through Industry Partnership: An Account of the Development of a Course in Structural Engineering Masonry Building Design

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Abstract

Academic partnering with industry is a paradigm shift that has taken many forms. The more recent discussions in this partnering paradigm shift concern the influence on the curriculum by the partnership. By partnering with industry during course development, up-to-date, and direct information on the current market place can be incorporated into the curriculum. Information that is typically gained through an internship can be gained by all students in the classroom. For engineering students of the built environment (e.g. civil, structural, or architectural), a recent partnership with industry identified a shortcoming in the traditional or typical structural engineering program. Typical structural programs usually offer students only two design courses – steel and reinforced concrete. However, the partnership identified the fact that when considering the built environment the majority of new construction is for structures around three stories or less. Such buildings tend to favor timber/masonry as the economical choice. And the consulting structural engineering profession has indicated a strong benefit for the student entering the market place who have had these preferred materials design courses. Industry has also indicated that students who have a more applied science and/or hands-on learning experience (robust) adapt quicker to work place environment. Considering the market place input from the partnership and wanting to offer students a more robust course offering, an engineering course in masonry design was developed with direct input from a professional industry association. Emphasis was placed on current industry practices – testing, quality of construction, and theory to code application. In addition, a mechanism was put in place for market place assessment over a 5 year span. This paper gives an account of partnering in course development.

Motivation

The more recent discussions in this partnering paradigm shift concern how industry could or should influence curriculum. At the 2013 Conference of American Society for Engineering Education (ASEE), Chinchilla investigated the question as a matter of ethics and saving industry training costs [1]. Ahzar et. al. noted how the academia-industry partnership can be used to advance the knowledge base in construction management education [2]. This paper demonstrates the positive affect of an academic-industry partnership and how the curriculum and teaching is directly influenced by the partnership – course selection, content, delivery method, and availability of resources.

The mission of the architectural engineering program at Cal Poly – San Luis Obispo is to educate students to enter and be successful in the practice of structural engineering, with an emphasis in seismic design. The program prides itself on going beyond traditional civil engineering structures education and thus took advantage of the opportunity to partner with industry in setting up a non-traditional curriculum.

Traditional structural engineering design curriculum has courses dedicated to steel and concrete only. Occasionally a course in timber can be found, but it is not common. The lack of course work in masonry and timber is not adequately supported when one considers that the majority of building construction is three stories and under, and the most common structural material for those building is masonry and timber. In addition, the Structural Engineer licensing examination requires the candidates to answer and pass design (breadth and depth) problems in timber/masonry besides steel and concrete[3].

The building industry has been proactive in meeting the changing needs and demands of society through design, engineering, and construction practices that result in safe, economical and sustainable structures. The American Institute of Architect (AIA) has taken a next step in sustainability by uniting the building industry with a commitment to resilient design[4]. Just as the building industry is proactive, engineering education must also be. One proactive step is to offer additional design courses in resilient structural materials.

When considering the prevalent use of masonry; the preparation of engineers for the masonry licensure questions; and masonry's high resilient quality (the next step in sustainability), a masonry design course is the obvious proactive step and would create a more robust engineering education. The authors partnered with industry in developing a curriculum for masonry design. The goals for the curriculum were to be efficient, pertinent, and give students practical experiences (i.e. hands-on experiences). In addition, it was the goal to format the course and its resources in such a manner that other institutions could easily adopt the course and offer students a more robust practical engineering education. A mechanism for assessment of student performance in the market place was also considered.

The Course Development

The partner for the course development was the Concrete Masonry Association of California & Nevada (CMACN) **[1]**. The organization serves as the leading concrete masonry data clearinghouse in the western states and facilitates up-to-date masonry information gathering and dissemination. As an example, the CMACN are publishers of the *Design of Masonry Reinforced Structures*[5] – a textbook that is appropriate for the classroom and used as a reference by practicing engineers. Included in the book are several practical design examples and aids.

The partnering was able to address the issue that the real world rarely reflects the "perfect" examples used in the theory of academia. It was agreed that it is best for the student to be introduced to a topic using the "perfect" examples of theory, but as quickly as possible the real world issues and challenges need to be brought into the teaching. The best way for the students to understand this is through hands-on experiences, with the partner providing guidance, access to industry, and resources.

The partnership lead to a series of goals for the curriculum development. These goals would set the frame work. The goals identified were:

- to incorporate hands-on practical student experiences where possible;
- interweave the governing building code with the theory;
- format the course such that other universities can readily adopt the course; and
- to provide a mechanism for assessment in the market place.

Hands-On Student Experiences

The industry partner was instrumental in planning the hands-on curriculum and providing the resources. All issues and possible problems in creating the hands-on experience were able to be identified and addressed by the industry partner. For faculty who are not intimate with industry, the partner was able to eliminate any guess work on the part of the instructor. In addition, the industry partner coordinated the delivery of materials and the availability of a professional masons.

Four student hands-on experiences were created to enhance and underscore construction quality on masonry properties and behavior. The four experiences were as follows:

Student Hands-On Experience 1: *A tour of a concrete block manufacturing plant to reinforce the industry terminology*. The tour gave the students access to an industry professionals who were able to convey the information and issues required for an engineer to assure their specifications can be met. For example, reduced cement content in a block is a sustainability measure that is becoming more common. The students were able to hear directly from the plant manager about the issues and requirements to reduce cement content. Another example was the students were able to see a whole stock of masonry products and feel the weight of different block sizes which is very important experience in masonry design. Below is a picture of the students at a local block manufacturing plant.

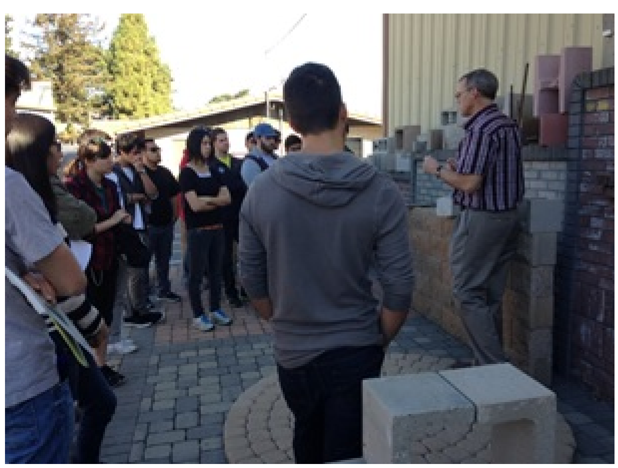

Figure 1: Students of the Masonry Design Course at a local block manufacturing plant.

Student Hands-On Experience 2: *Actual mixing of mortar from raw ingredients and construction of a masonry test prism.* Through this experience the students begin to see how the written specifications can affect the actual construction. For example, what is meant in the specification, "to add enough water to make a workable mix?" Below are a sequence of pictures showing mixing of mortar and building test prisms.

Figure 2: Dry Ingredients

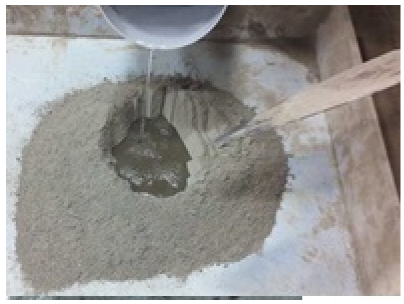

Figure 3: Adding Water

Figure 4: Proper Mix

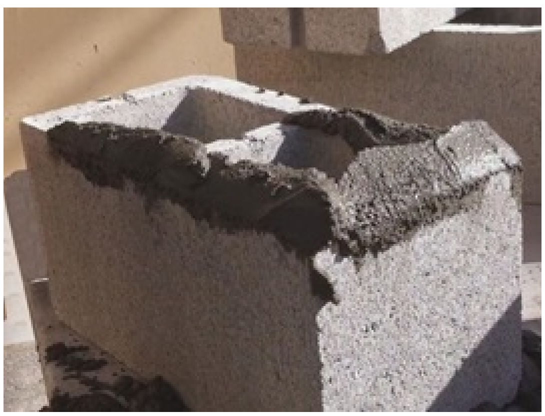

Figure 5: Buttering the Block

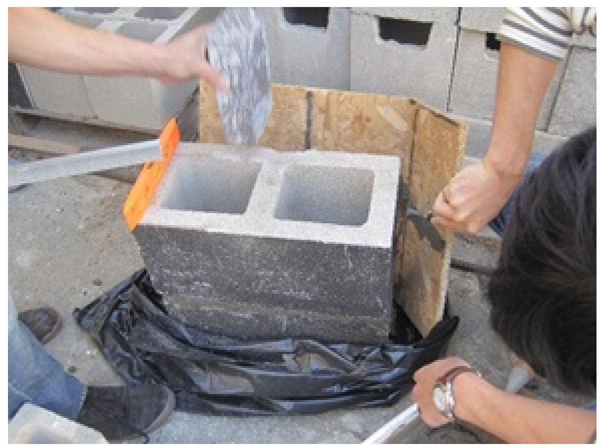

Figure 6: Level the Prism

Student Hands-On Experience 3: *The construction of a masonry wall with a professional mason*. By working directly with a professional mason, the student saw how the paper design actually transferred to reality. Such issues as dimensions (conform to block unit dimensions) and reinforcement bar clearance can have a great negative impact on project if not properly considered in the paper design (see Figure 7 – next page).

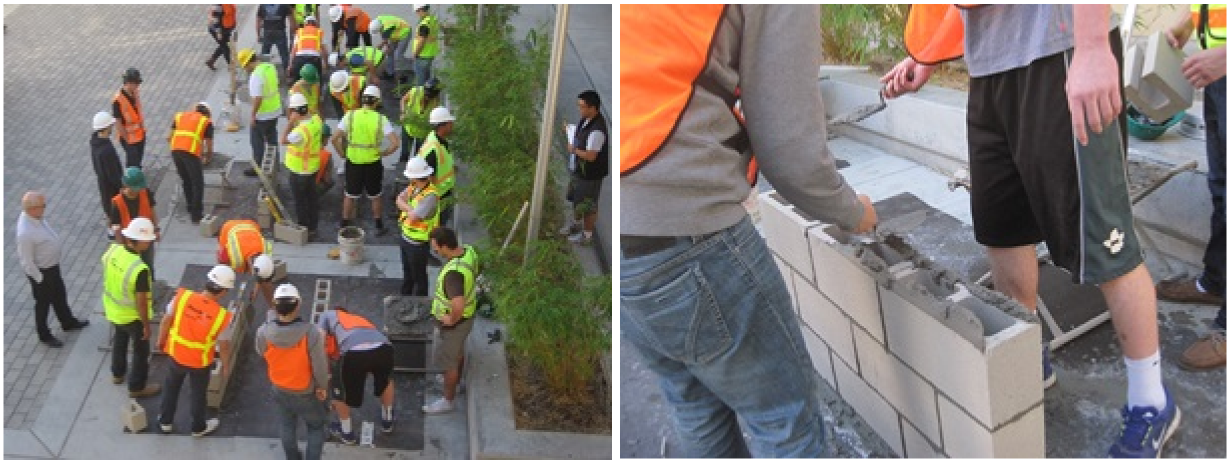

Figure 7: Student work directly with professional masons

<u>Student Hands-On Experience 4:</u> *The testing of prisms.* The prism test allowed the students to gain an understanding of code values versus actual. Since the students constructed the prisms, the students were able to witness how the quality of construction affected the compression values. The students were also able to determine the compressive strength of mortar cylinders and individual blocks and to compare the individual strengths to that of the prisms (assembly) tested as shown in Figure 8 below.

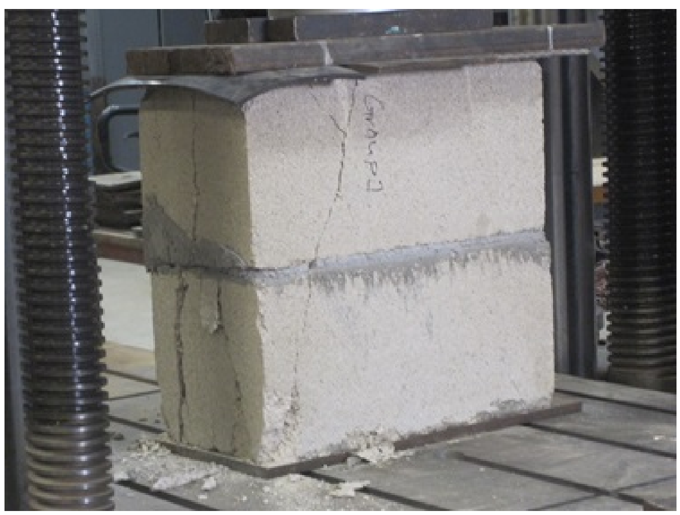

Figure 8: Compressive testing of masonry prism

Governing Codes and Theory

To emphasize the practical application of the course, the textbook required for the course was written by adjunct college professors who are practicing structural engineers. The content of the textbook quickly goes from the theory of masonry design to the implementation of the theory through code application. In review of the textbook, the partnership was able to identify the need for component of the course to include "load flow".

It is typical for design course to present students with design problems that have loading given. Again, this is can be used for introducing a concept, but it does not reflect reality. Determining the loading is a major part of structural design, and the partnership agreed the student should be made known of this fact. A component of the course lecture included “load flow”.

The International Code Council (ICC) reference document for the masonry building code (TMS 402) [2] was integrated throughout the curriculum. The code book was provided to each student by the industry partner free of charge. Figure 9 below show the course text books which were donated by the industry partner.

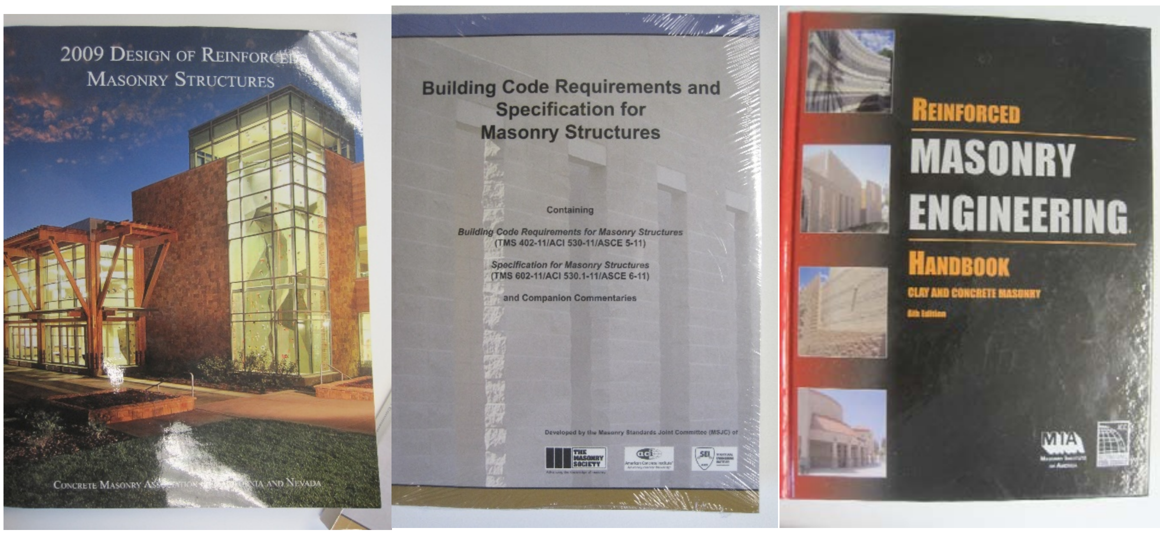

Figure 9: Course Textbooks

<u>Formatting the Course</u>

One of the goals of the course development was to format the course documentation such that the course could easily be incorporated by other universities. By including a partner in the course development, an outside pair of eyes was available to assure the course did not include nuances of our own facilities and department practices.

The course documentation included:

- a syllabus that can conform to the semester or quarter system and 2 or 3 unit course;
- board notes for the instructor for each lecture;
- power point presentations for non-traditional topics and hands-on activities;
- homework and exams examples; and
- resources required for hands-on activities.

The industry partner committed to providing the resources to the students.

Mechanism for Assessment in the Market Place

The benefit in creating a curriculum with an industry partner is the ability to identify the market place components that have changed over time and how best to benefit the student education. This partnership was able to identify a need for a more robust course offering to "keep up" with the changes in sustainable design and to allow the engineering student to have a bigger impact in the market place. Since the market place is continually changing, the impact of the design course has to be assessed. Assessing student success in the market place is a long term task. The industry partner is aware of this and has committed resources and funding to assist universities who would like to participate in adding a yearly course offering in masonry design and assessing the student success in the market place [1].

The template for implementation is to provide participating universities with course materials, hands-on experience resources and funding, such that time and financial impacts are minimized. The template for assessment is to meet every year (for five continuous years) during the summer and come to a consensus.

Conclusion

In the development of the Masonry Design course, a current market place component of education was brought directly into the curriculum through hands-on experiences and practical application of classroom theory. The industry partner was able to identify issues for implementation and readily commitment to providing necessary resources – resources beyond the traditional classroom. In this case the resources included building materials, coordination administration, access to industry facilities, code books, textbooks, and funding.

In regards to the actual course content, non-traditional classroom ideas were explored and a framework for development was created where academic theory was used to introduce a topic and real world application used to apply the theory. The framework for Masonry Design course was as follows:

- Incorporate hands-on practical student experiences where possible.
- Interweave the governing building code with the theory.
- Disseminate information by formatting the course for use by other universities.
- Provide a mechanism for assessment in the market place.
- Design curriculum with the knowledge and resources from supporting industry.

The industry partnership for the Masonry Design course has shown success to date. The market place assessment is for further research - contact CMACN [1] for additional information and to participate.

The annual summer meetings, will be used as a venue to discuss course improvements such as learning management systems and possible future areas of consideration like hybrid and/or online components of the class.

End Notes

[1] Concrete Masonry Association of California & Nevada; 6060 Sunrise Vista Dr., Suite 1990, Citrus Heights, CA 95610; http://www.cmacn.org/

[2] Building Requirements for Masonry Structures (TMS 402); The Masonry Society,105 South Sunset St, Suite Q, Longmont, CO, 80501; http://www.masonrysociety.org/

References

1 Chinchilla, R.; *Collaboration between private sector and academia: Are we compromising our engineering programs?*; ASEE Annual Conference and Exposition, Conference Proceedings, 2013, 120th ASEE Annual Conference and Exposition; June 23-26, 2013 - June 26, 2013.

2 Ahzar, S., et. al.; *State-of-the-Art Best Construction Practices Integration into Higher Education Curricula*; Journal of Professional Issues in Engineering Education and Practice, 2014.

3 NCEES; *Lateral Forces (Wind/Earthquake) Component of the Structural Engineering DEPTH Exam Specifications*; Retrieved from http://ncees.org/exams/se-exam/

4 Singer, M.; *Resilience is the Next Step on the Path to Sustainability*; AIA National Convention, June 26-28, 2014, Chicago, IL; Retrieved from http://www.aia.org/practicing/AIAB104191.

5 Ekwueme, Hart, and Brandow;*Design of Reinforced Masonry Structures*; Concrete Masonry Association of California and Nevada, Citrus Heights, CA.